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WATER SUPPLY ASPECTS OF THE PROPOSED LAKE KEMP REHABILITATION, WICHITA RIVER, TEXAS

Public Health Service
Dallas, Texas

July 1960

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WATER SUPPLY ASPECTS

OF

PROPOSED LAKE KEMP REHABILITATION

WICHITA RIVER

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Tulsa, Oklahoma

JULY 1960

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INTRODUCTION

Authority and Scope

Under provisions of the Memorandum of Agreement between the Department of the Army and the Department of Health, Education, and Welfare, dated November 4, 1958, the Public Health Service provides assistance in implementing the Water Supply Act of 1958 (Title III, Public Law 500, 85th Congress). By letter dated 23 October 1959, the U. S. Corps of Engineers, Tulsa District, requested of Public Health Service a report on the water supply aspects of Lake Kemp, including water quality, needs, and value.

Acknowledgments

The assistance of representatives of the following groups and agencies is gratefully acknowledged:

City of Wichita Falls, Texas

Texas State Department of Health

Texas Board of Water Engineers

Wichita County Health Department

Wichita County Water Control and Improvement District Number One

Wichita Falls Chamber of Commerce

SUMMARY AND CONCLUSIONS

Summary

1. Lake Kemp is formed by an existing non-Federal dam, built in 1923 on the Wichita River, about 40 miles west of Wichita Falls, Texas. It has a limited present use for irrigation and some industrial processes.

2. The Corps of Engineers is making an investigation to determine the advisability of Federal rehabilitation of the project to provide for flood control in addition to conservation aspects. Currently under consideration is the possibility of allocating 190,000 acre-feet of conservation storage which might be used for irrigation, for municipal and industrial water supply, or both.

3. The potential user of M & I water from the project is the city of Wichita Falls. Its population is expected to reach 310,000 by the year 2010. Corresponding water needs will be about 70 mgd, of which an estimated 20 mgd can be met from the existing sources of Lakes Kickapoo and Wichita.

4. It is the opinion of the Public Health Service that the quality of water in the Wichita River at Lake Kemp is, at present, unsatisfactory for municipal supply, because of the high concentration of chlorides and sulfates.

5. Studies are in progress by the Public Health Service in the Red River Basin to determine the location, nature, and extent of sources of contamination. These studies will not be completed until about 1963. However, it has been established that the contamination at Lake Kemp is principally of natural origin and is concentrated in three groups of salt springs, one on each of the three forks of the upper Wichita River. The Public Health Service and the Corps of Engineers are concurrently studying methods for the containment of pollutants from these sources, to make the downstream water quality satisfactory.

6. Estimates of the firm yield from conservation storage at Lake Kemp made by the Corps of Engineers show a potential of 62 mgd from 190,000 acre-feet of conservation storage.

Conclusions

1. If the mineral concentrations can be reduced to acceptable maxima, there will be a definite need for storage in Lake Kemp for M & I water supply. The project is ideally situated to serve the city of Wichita Falls, which will need a supplementary supply within the next ten years, and will require an estimated 50 mgd of additional supply by the year 2010.

2. The benefits from storage in Lake Kemp for municipal and industrial water supply would be about $1,060,000 per year, for a firm yield of 50 mgd. This is based on the cost of developing an alternative supply at the Ringgold site on the Little Wichita River. However, this value pertains only if the quality problem is overcome.

3. Unless the quality of water entering Lake Kemp can be improved, by the control of upstream natural pollution at its source, storage for water supply will have negligible value.

DESCRIPTION OF AREA

Lake Kemp is located in north central Texas, about forty miles west of Wichita Falls. It was formed by a dam built in 1923, currently operated by Wichita County Water Control and Improvement Districts Number One and Number Two. It has limited present use for irrigation and some industrial processes.

The Corps of Engineers is investigating the advisability of Federal rehabilitation of the project, for flood control and conservation purposes. For preliminary planning purposes, the proposed modification includes provision of 190,000 acre-feet of storage in the conservation pool, along with 200,000 acre-feet for flood control and 136,000 acre-feet for sedimentation allowance.

The terrain of the region is generally rolling with elevations ranging between 800 and 1,000 feet. It is part prairie and part timbered with post oak and mesquite. Precipitation averages 27 inches annually, but the evaporation rate is high due to high temperature and wind velocity during the period of greatest rainfall.

The economy of the area exhibits considerable diversity. The primary sources of economic activity are agriculture, mineral extraction, manufacturing, and military employment.

There are several small communities in the area. Wichita Falls with 101,000 is the only large city. All others are less than 6,000 population.

ECONOMICS AND POPULATION

The principal water demand center for Lake Kemp is the city of Wichita Falls, Texas. The population and industrial growth of Wichita Falls and the consequent water demand will depend in large part upon the presence of natural resources, the pattern of industrial development in the area, and the growth of the market. The demographic and economic analysis of the county within which Wichita Falls lies and the two counties immediately adjacent to it will help explain the past growth trends of this city and will also give a good indication of the future growth potential. The three counties in this primary area of influence are Archer, Clay, and Wichita Counties. The first part of this chapter shows the trend of the various segments of the economy and the resultant development in the three-county area and the city of Wichita Falls. The second part of the economic analysis covers growth prospects.

Extractive Industries

Minerals

The extraction of mineral resources is an important activity in the economy of the three-county area. The total value of petroleum, natural gas, and natural gas liquids extracted in the three counties has been averaging $80,000,000 annually for several years. (See Table 1.)

Table 1

Value of Mineral Production 1/
Archer, Clay, and Wichita Counties, Texas
1952-1958
(Figures in millions of dollars)

Counties	1952	1953	1954	1955	1956	1957	1958
Archer	$29	$27	$26	$26	$28	$29	$30
Clay	13	14	16	19	19	18	17
Wichita	33	38	38	32	33	35	35
TOTAL	$75	$79	$80	$77	$80	$82	$82

Production of petroleum will continue for many years. In the oil fields for which data are available, estimated resource reserves are sufficient in the three counties to sustain the present rate of extraction (primary recovery) for eighteen years.[2] Secondary recovery operations will extend this time considerably. Explorations are continuing; during 1957-1958, 2,683 wells were drilled, of which 1,637 were producing wells. In addition to petroleum and gas, there is some extraction of stone, sand, and gravel.

Agriculture

The role of agriculture in the economy of the three-county area has been declining. Not only has the number employed in agriculture been decreasing but the number of farms, the acreage of croplands harvested and the value of crops and livestock sold have also been decreasing. The number of farms has steadily decreased from 3,267 in 1945 to 2,160 in 1954. Although the average size of the farms has increased from approximately 590 acres to 830 acres during this period, thereby appearing to compensate for the decrease in the number of farms, the amount of farm production fell off significantly. The acreage of cropland harvested dropped from 317,000 acres in 1944 to 308,000 in 1949 and continued to drop to 221,000 in 1954. The value of crops and livestock sold increased between 1944 and 1949 but declined 22 per cent between 1949 and 1954. (See Table 2.) The net result has been a decrease in the physical volume of production of approximately 19 per cent between 1949 and 1954. Since 1954 the declining trend in agriculture seems to be continuing. The number in the labor force working on farms was approximately 3,600 in 1955 and 3,500 in 1959.[4]

Table 2

Value of Crops and Livestock Sold[3]
Archer, Clay, and Wichita Counties, Texas
1944, 1949, 1954
(Figures are in thousands of dollars)

Year	Value of Crops Sold	Value of Livestock Sold	Total
1944	3,015	6,167	9,182
1949	5,231	13,217	18,448
1954	4,338	9,982	14,320

Manufacturing Industries

The location of manufacturing firms in the three-county area is confined almost entirely to the city of Wichita Falls. Both in terms of employment and value added by manufacture, Wichita Falls has over 95 per cent of the total manufacturing activity in the three-county area. The manufacturing base of Wichita Falls has had an expanding trend. The number and size of firms engaged in manufacturing, the number of employees, and the value of the output have all increased. The number of firms employing twenty or more workers increased from nine in 1947 to eleven in 1954, then jumped to forty-one in 1958. Between 1947 and 1958 the value added by manufacture increased from $21,648,000 to $28,193,000. 4/

Wichita Falls' industrial base is becoming increasingly diversified. There are firms employing twenty or more persons in the following industrial groups: food and kindred products, apparel and related products, lumber and wood products, printing and publishing industries, chemical and allied products, petroleum and coal products, primary metal industries, fabricated metal products, machinery (except electrical), and transportation equipment.

During the last several years over one million dollars annually have been invested in capital expenditure for plants and equipment.

Trade and Service Industries

Commercial development has coincided with industrial advancement. The retail, 6/ wholesale, 7/ and service 8/ establishments have shared in the growth of the three-county area, as evidenced by the increase in the number of establishments, employment, and sales. Most of the growth was experienced in the city of Wichita Falls where employment and the number of establishments each increased 35 per cent between 1948-1958. Sales increased 51 per cent from $151,000,000 to $228,500,000.

Government Employment

The U. S. Government is the largest single employer in Wichita Falls. In 1950 approximately 13,500 of a labor force of 36,300, or 37 per cent, were employed by the Federal Government. 9/ The majority of these, 12,500, were military personnel stationed at nearby Shepherd Air Force Base. In May, 1960, the number of military personnel on duty was 15,000. Of these it is estimated that from 6,000 to 7,000 live in Wichita Falls.

Population

The population of the three-county area, exclusive of the city of Wichita Falls, had a declining trend between 1920 and 1950.[9/] The decrease from 54,950 in 1920 to 47,147 in 1950 was primarily due to diminution of agricultural production and the decrease of employment directly or indirectly resulting therefrom.

A contrasting trend is indicated in Wichita Falls. Its population has more than doubled from 45,112 in 1940 to 101,000 in 1960. Much of this growth resulted from the establishment of Shepherd Air Force Base in 1941. It is estimated that in 1960 approximately 16,000 Air Force personnel and their dependents live in Wichita Falls. Also contributing to the population increase has been the annexation of adjacent unincorporated areas, the expansion in the industrial base, and the accompanying increase in commercial and service employment.

Future Growth Prospects

The population of the nation is expected to double between 1960 and 2010. This will mean a vast increase in the need for goods and services in the next fifty years. All parts of the nation will continue to contribute to the needs, but the rate of increase in production will not be uniform in all areas. The more favorably a community is endowed with factors which enhance its ability to produce and distribute goods and services, the greater will be its likelihood of growth. An examination of the ability of the study area to meet the increased demands will assist in forecasting the future growth of Wichita Falls. This section will cite the growth expectations in the extractive, manufacturing, and service industries and the resultant population prediction.

The area is endowed with some natural resources for which a considerable increase in demand is anticipated, particularly petroleum and natural gas. Estimated reserves will permit the present high rate of petroleum and natural gas extraction to continue for many years. Increased agricultural activity is also anticipated. Aside from stimulating employment in extractive industries, these reserves will serve to encourage expansion in processing and manufacturing activities. Production is expected to increase in resource-based industries, particularly in food processing, chemicals, and petroleum products. In addition, market-oriented manufacturing firms will be established as population in the market area increases. The most promising are apparel, metal products, and machinery. Likewise, trade and service industries will continue to grow with the area. The economic climate for industrial and commercial growth is favorable. The local as well as the national markets are expanding.

Good transportation facilities are available. Wichita Falls is served by both rail and an excellent highway system. Fuel and power are available at relatively low cost. The area has ample reserves of natural gas. Labor supply likewise is no problem. Labor of all skills will move into this and other areas as opportunities develop. Indications are that Wichita Falls is favorably situated to enjoy a rate of growth commensurate with that of the average for the nation's metropolitan areas. The population projected for Wichita Falls, Texas, in the year 2010 is 310,000.

PRESENT WATER SUPPLIES

Sources

Prior to 1946, Wichita Falls received all of its water from Lake Wichita. This lake, on Holliday Creek adjacent to the city, was purchased by Wichita Falls in 1920. It has a storage capacity of some 15,000 acre-feet and a drainage area of 143 square miles.

In 1946 Lake Kickapoo on the Little Wichita River was placed in service as the principal source of water for Wichita Falls; Lake Wichita remained in service for supplementary use. Kickapoo Reservoir has a drainage area of 275 square miles and a storage capacity of 106,000 acre-feet. 10/

The safe yield, through critical drouth periods, of the Kickapoo storage volume has been variously estimated by different persons. The range of estimated yields, from 15 to 22 mgd, is indicative of the approximate nature of such estimates. The amount by which storage may be reduced by siltation, and the amount of storage to be held in reserve as a factor of safety, are the chief ponderable questions. Officials of Wichita Falls, guided by recommendations of their consulting engineers 11/, consider Lake Kickapoo to have a safe yield of 16 mgd. To this they have added an estimated 4 mgd from Lake Wichita, for a total of 20 mgd.

For the purposes of this study, a combined safe yield from present sources of 20 mgd, as reported by the city and published in the inventory of municipal water facilities 12/, has been adopted.

Quality

Organic pollution is not a serious problem at any of the reservoirs under consideration, as there are no heavy concentrations of population or industry on the watersheds. The quality problem centers on the concentrations of chemical constituents, notably chlorides and sulfates, and on total dissolved solids. Table 3 (from the Lake Wichita Report 10/) shows the comparative chemical quality of waters from Lakes Kickapoo, Wichita, and Kemp.

Table 3

Water Quality of Lake Kickapoo, Lake Wichita, and Lake Kemp
(From Records of Wichita Falls Water Treatment Plant)

Date	Point	Chlorides (ppm)	Total Dissolved Solids (ppm)	Total Hardness (ppm)
5/18/53	Lake Kickapoo	26	288	122
5/17/54	Lake Kickapoo	20	229	112
8/19/54	Lake Kickapoo	19	249	110
11/18/54	Lake Kickapoo	18	203	98
3/30/55	Lake Kickapoo	20	276	118
2/24/56	Lake Kickapoo	17	222	96
5/17/54	Lake Wichita	216	552	182
3/31/55	Lake Wichita	366	941	274
11/18/55	Lake Wichita	164	474	144
2/17/59	Lake Wichita	460	1,020	-
5/25/59	Lake Wichita	580	1,200	-
11/17/54	Lake Kemp	740	1,924	-
3/31/55	Lake Kemp	670	1,733	-
11/18/55	Lake Kemp	488	1,262	-

The Public Health Service drinking water standards 13/ recommend that the concentration of chlorides not exceed 250 parts per million (ppm). A similar maximum concentration is recommended for sulfates. For total dissolved solids, a maximum of 500 ppm is desirable, with up to 1,000 ppm permissible if better quality water is not available.

It will be seen that Lake Kickapoo is satisfactory for water supply by the above standards, but Lakes Wichita and Kemp are not. Water from Lake Wichita (with its present quality) can be used to supplement the supply from Kickapoo, as long as the two supplies are blended before distribution. In such event, it is recommended that the blend contain at least three parts of Lake Kickapoo water for each part of Lake Wichita water.

The principal sources of pollution to Lake Wichita are brine solutions from oil field operations on the watershed. Presently known oil-well operation technology is such that this man-made pollution could be prevented. It is reasonable to expect that the administrative and enforcement details for a pollution abatement program will be worked out by the state agencies concerned with the problem. Therefore, it may be anticipated that Lake Wichita water will be made more acceptable in the future [10]. A different problem exists at Lake Kemp, as will be subsequently discussed.

Quantity Used

Average daily water requirements of Wichita Falls have tripled since the middle of the 1930 decade. Historical use, as shown in Table 4, remained fairly constant during the 1930's, but has increased steadily since that time. An average consumption rate of 13.3 mgd was reached in 1956.

Based on an estimated population of 98,000 in 1956, the average per capita consumption was 136 gallons per day. This includes most of the industrial use in the area. Present water needs of industry are not heavy, and are obtained largely from the city of Wichita Falls.

Table 4

Wichita Falls Water Consumption, 1930-59
(From Records of Wichita Falls Water Treatment Plant)

Year	Average (mgd)	Year	Average (mgd)
1930	4.094	1945	6.467
1931	3.632	1946	6.508
1932	3.157	1947	5.884
1933	3.133	1948	6.388
1934	3.692	1949	7.132
1935	3.145	1950	7.728
1936	3.690	1951	10.633
1937	3.511	1952	12.138
1938	3.712	1953	10.311
1939	4.026	1954	10.699
1940	3.915	1955	10.846
1941	3.978	1956	13.298
1942	5.649	1957	10.596
1943	7.299	1958	11.216
1944	6.216	1959	11.5

FUTURE WATER SUPPLIES

Quantity Requirements

As projected for the Lake Wichita study [10/], municipal and industrial water needs for the area are expected to reach approximately 70 mgd by the year 2010. Past usage and projected future requirements are shown graphically on Figure 1. As previously mentioned, present sources in Lakes Kickapoo and Wichita can supply about 20 mgd of this total. New sources will be required to supply the additional 50 mgd.

Possible Sources

Additional supply would logically be obtained from surface water impoundment on the Wichita River, the Little Wichita River, or both. Potential sites exist on the Little Wichita, downstream from the existing Lake Kickapoo, known as the Scotland site and the Ringgold site. Studies of these two sites have been made by the U. S. Bureau of Reclamation, and by Freese and Nichols, consulting engineers.

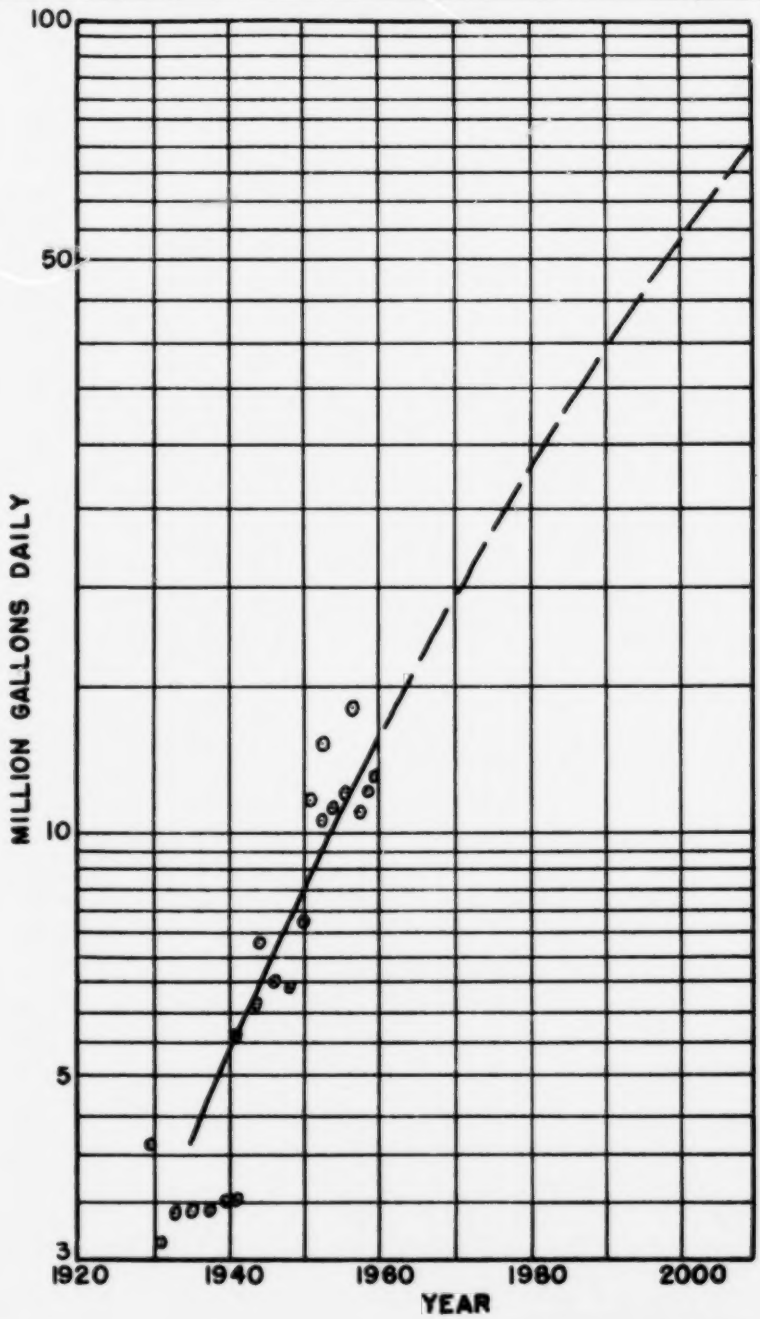
Each of the above study groups concluded that the Scotland site would be preferred if the quantity needed was not more than 30 mgd; but, if th need was greater, then the Ringgold site would be better in the long run. The Scotland site, although closer to Wichita Falls, is upstream from the Ringgold site, has a smaller intervening drainage area (below Kickapoo), and therefore a lower potential yield.

On the "big" Wichita River, the logical site for impoundment would be the rehabilitated Lake Kemp, which is under study.

Lake Kemp As a Source

Since Wichita Falls is on the Wichita River and Lake Kemp is some 40 miles upstream, the Lake is well located to serve as a water supply source. Transmission costs would be minimal, since water could flow by gravity down the natural channel.

Unfortunately, the water of the Wichita River (including Lake Kemp) is too highly mineralized to be acceptable as a source of municipal supply. This is part of a general problem on the Red River, of which the Wichita is a tributary.



LAKE KEMP
WATER REQUIREMENTS
WICHITA FALLS, TEXAS

U.S. DEPARTMENT OF
HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 1

In February of 1957, the Public Health Service, in cooperation with the Texas State Department of Health, began pilot studies of the water quality problem in the Red River basin. Subsequently, this work has expanded to bring in other agencies, and its scope has been enlarged to include the Arkansas River as well as the Red.

These investigations are still in progress, and it is expected that they will be completed in 1963. Their purpose is to determine the location, nature, and extent, of sources of contamination; and to determine methods by which, with cooperative effort, improvement of water quality may be accomplished.

It has been established that the contamination of Lake Kemp is principally of natural origin; it is concentrated in three groups of salt springs, one on each of the three forks of the upper Wichita River. An indication of the present quality of water from Lake Kemp is given in Table 5. This table summarizes the results of samples collected and analyzed by the Arkansas-Red River Basin study group.

Table 5

Quality - Water Leaving Lake Kemp
(Arkansas-Red River Basin Study Group)

Date	Number of Samples	Average Flow (cfs)	Chlorides		Sulfates	
			Wt'd. Av. (ppm)	Av. Tons per Day	Wt'd. Av. (ppm)	Av. Tons per Day
10-59	3	230	1,020	631	---	---
11-59	2	72	900	174	570	110
12-59	5	55	969	144	538	80
1-60	4	3.1	847	7.1	561	4.7
2-60	4	3.2	821	7.1	520	4.5
3-60	5	44	908	108	538	64

The Corps of Engineers has estimated that a storage volume of 190,000 acre-feet at Lake Kemp would provide a firm yield of about 62 mgd.

Monetary Value of Storage in Lake Kemp

Evaluation of benefits for water supply storage in Lake Kemp is based on comparison with the Ringgold site on the Little Wichita River as an alternative.

The cost of storage at Ringgold, for a yield of 50 mgd would be about 3.2 cents per thousand gallons by interpolation of cost estimates made by the Bureau of Reclamation, adjusted to 1960 construction costs. Adjustment must be made for the difference in transmission cost due to the less favorable location of Ringgold as compared to Lake Kemp.

The major differences in transmission costs are (1) the capital cost of some 26 miles of 54-inch pipeline, and (2) additional energy cost for pumping, to overcome extra frictional resistance equivalent to 151 feet of head plus 90 feet of static lift. The first of these reduces to about 1.14 cents per thousand gallons, and the second to about 1.45 cents, assuming average cost of electric energy at 1.2 cents per kilowatt hour.

The gross value of storage in Lake Kemp is, therefore, on the order of 5.8 cents per thousand gallons of yield of water of acceptable quality. Corresponding annual benefit for a 50-mgd yield is $1,060,000.

Unless and until some method is developed for the containment of pollution from the upstream salt springs, storage of this water will have negligible value for municipal purposes. Certain industries might be able to make selective use of the highly mineralized water for some purposes; but it is believed that strong preference would be shown for development of a source of water whose quality was satisfactory for all ordinary uses.

Summarizing, the benefit from storage in the project for water supply is 7.3 cents per 1,000 gallons if quality is satisfactorily improved, and negligible if it is not. It follows that the justifiable expenditure for storage should not exceed this benefit figure reduced by the cost of quality improvement measures.

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